
Crystal growth of YBCO coated conductor under low pressure

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Introduction

Problems to be solved

- **Low growth rate of c-axis oriented grains**► **long processing time**
- J_c decrease with increasing the film thickness
- Low mechanical strength

- The volume fraction of a-axis grains becomes larger with increasing the growth rate and that lowers J_c/l_c
- Boundary of stable growth regions between c-axis grains and a-axis grains; 2 nm/s (Suenaga *et al.*)

Recent result;

- **Low pressure conversion helps c-axis oriented grains to grow faster**

Experimental

MOD derived precursor film (0.8 μm thickness) on buffered RABiTS substrate (supplied by AMSC)



Conversion in atmosphere controlled RTA furnace



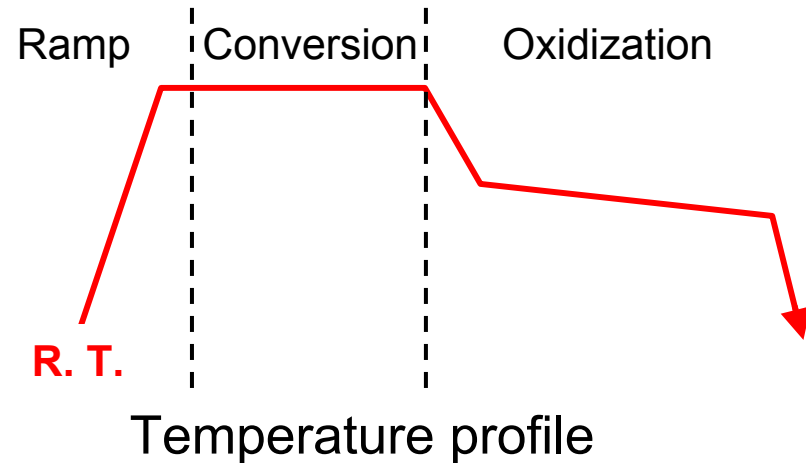
Heating conditions during Ramp and Conversion:

P_{total} ; 173 Pa

P_{O_2} ; 133 Pa

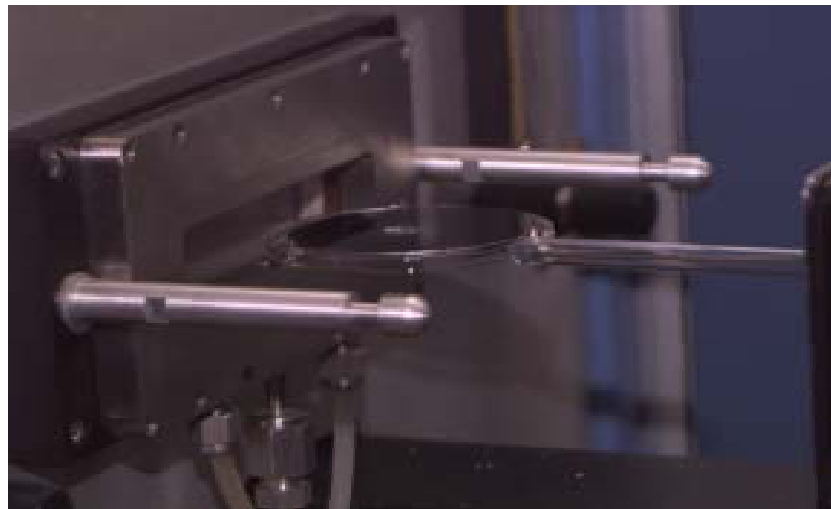
$P_{\text{H}_2\text{O}}$; 1.3~40 Pa

Ramp rate; 76~1500 K/min



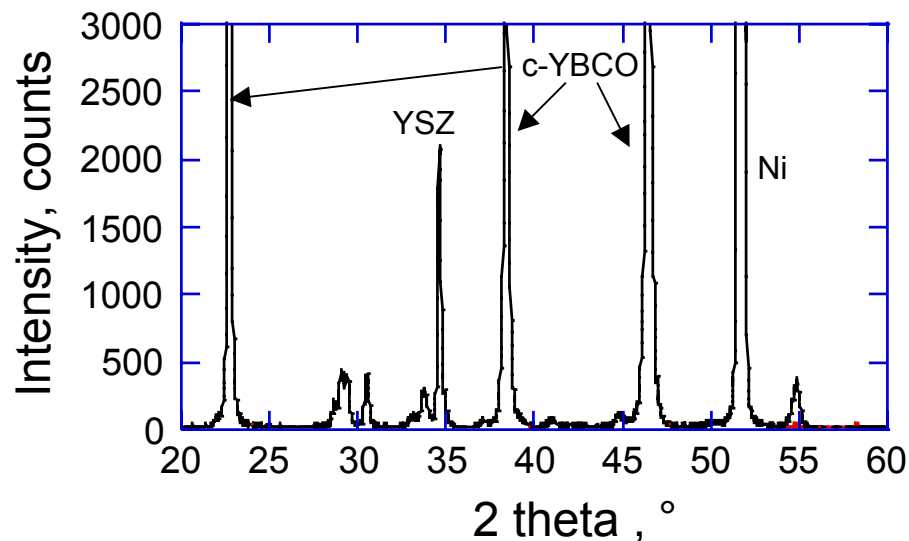
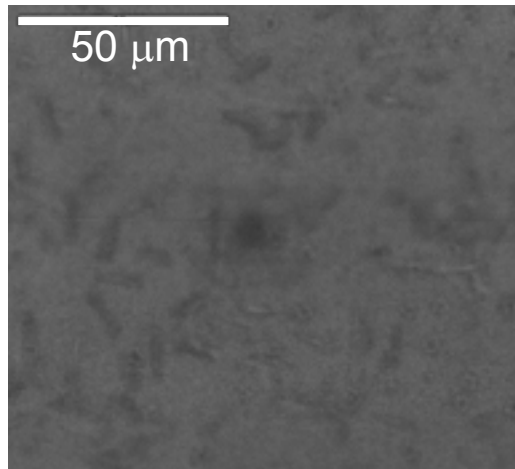
Measurement (SEM, XRD, I_c)

Rapid Thermal Annealing Equipment



Ceramic Processing Research Laboratory
Massachusetts Institute of Technology

Low pressure conversion



SEM image and XRD pattern of coated conductor converted under low total pressure

P_{total} ; 173 Pa (0.0017 atm)

P_{O_2} ; 133 Pa

$P_{\text{H}_2\text{O}}$; 40 Pa

Ramp rate; 380 K/min

Conversion; 785 $^\circ\text{C}$, 2min



$$\begin{aligned} \text{Gr. Rate} &> 800_{\text{nm}} / 130_{\text{sec}} \\ &= 6.1 \text{ (nm/sec)} \gg 2 \text{ (nm/s)} \end{aligned}$$

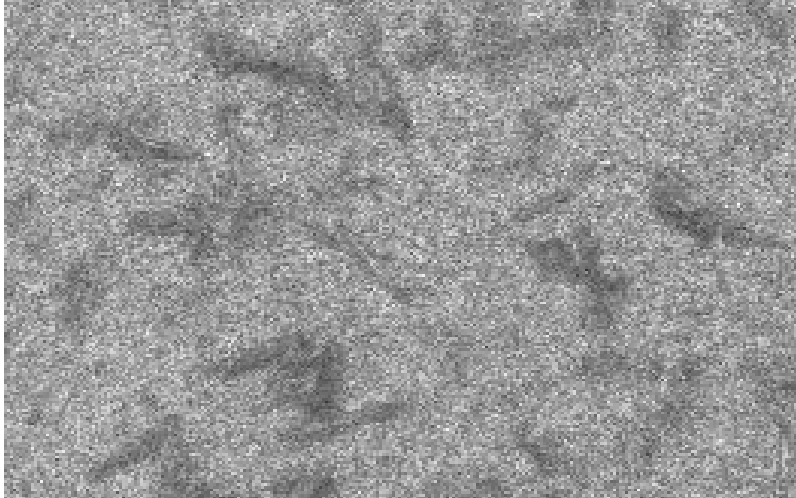
C-axis oriented YBCO film **CAN** be grown faster than 2nm/s by using the low pressure conversion.

Typical results for RABITS substrate, 0.8 micron YBCO

Temp. C	Low PH ₂ O	High PH ₂ O mTorr	PO ₂ (~total P); Torr	Time at Moist (min)	I _c	ramp	net growth rate (nm/s)
785	25mTorr	230	1 Pure O ₂	2low/3full	82.6A	2min to 785	>2.67
785	200	200	1 Pure O ₂	3full	134.5A	2min to 785	>4.44
785	25	250	1 Pure O ₂	3low/2full	82.5A	2min to 788	>2.67
785	25		1 Pure O ₂	7low	90.6A	10min to 785	>1.9
785	10	300	1 Pure O ₂	2low/1full	44.4A	2min to 785	>4.44
785	300	300	1 Pure O ₂	2full	135.1A	2min to 785	>6.67
785	10	300	1 Pure O ₂	2low/1full	41.5A	10min to 785	>4.44

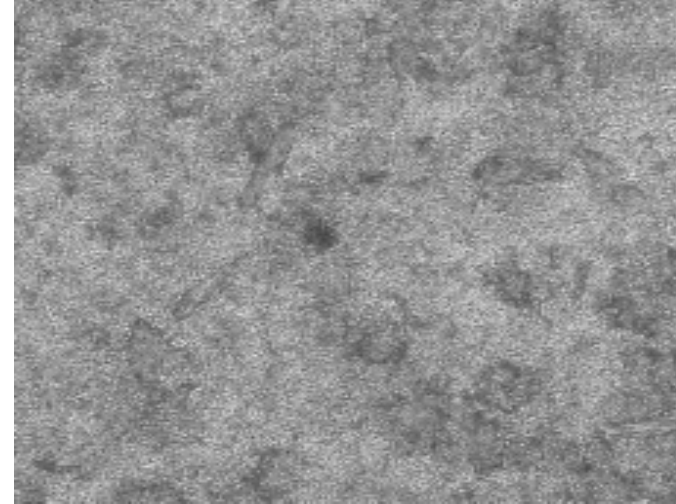
Effect of $P_{\text{H}_2\text{O}}$

100 μm



40 Pa PH_2O

135A(108 A/cm-width)

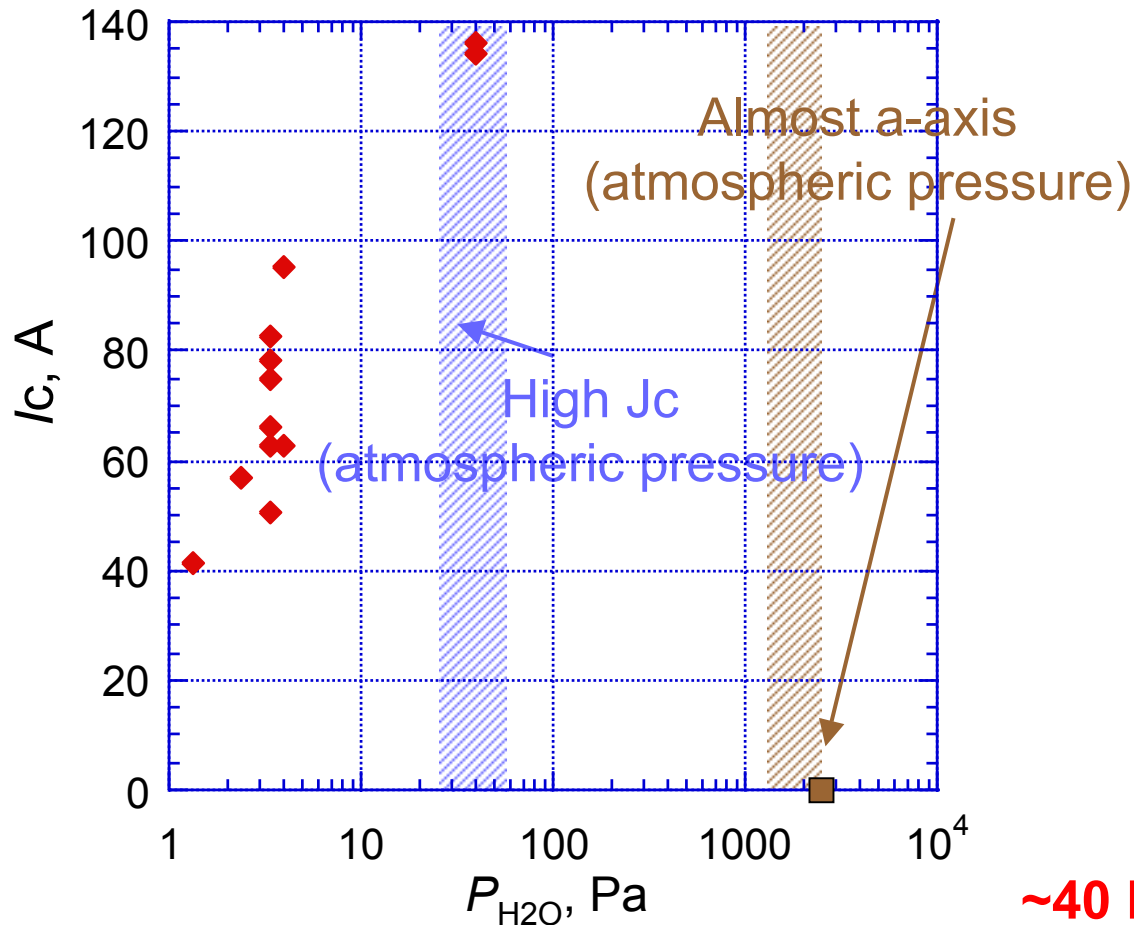


2.4 Pa PH_2O

56.9A(45.5 A/cm-width)

I_c decreased by lowering the $P_{\text{H}_2\text{O}}$ from 40 Pa to 5 Pa under low total pressure atmosphere.

Effect of $P_{\text{H}_2\text{O}}$



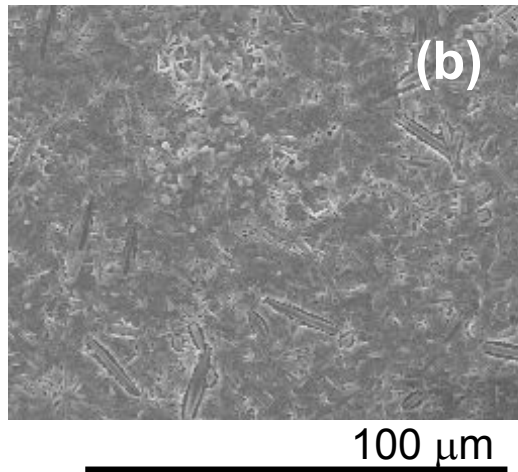
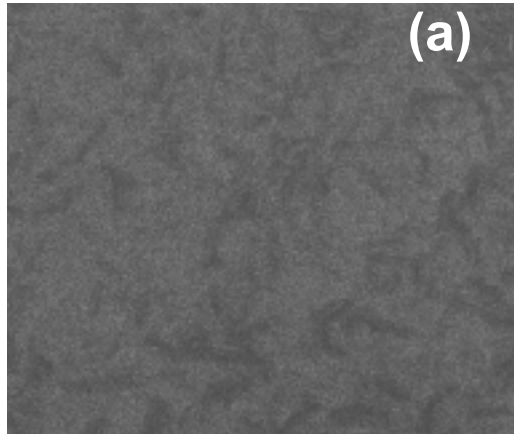
$P_{\text{H}_2\text{O}}$ dependence of J_c

- J_c value increases with increasing $P_{\text{H}_2\text{O}}$ under 133 Pa total pressure.

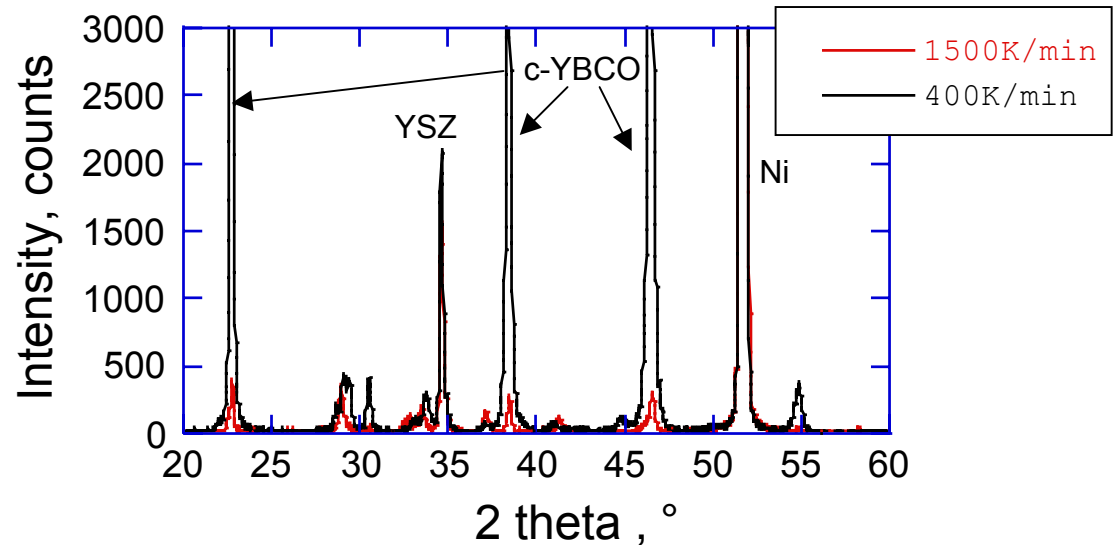
- J_c increases with decreasing $P_{\text{H}_2\text{O}}$ under atmospheric pressure.

~40 Pa $P_{\text{H}_2\text{O}}$ atmosphere could be the optimum for highest J_c

Effect of Ramp rate



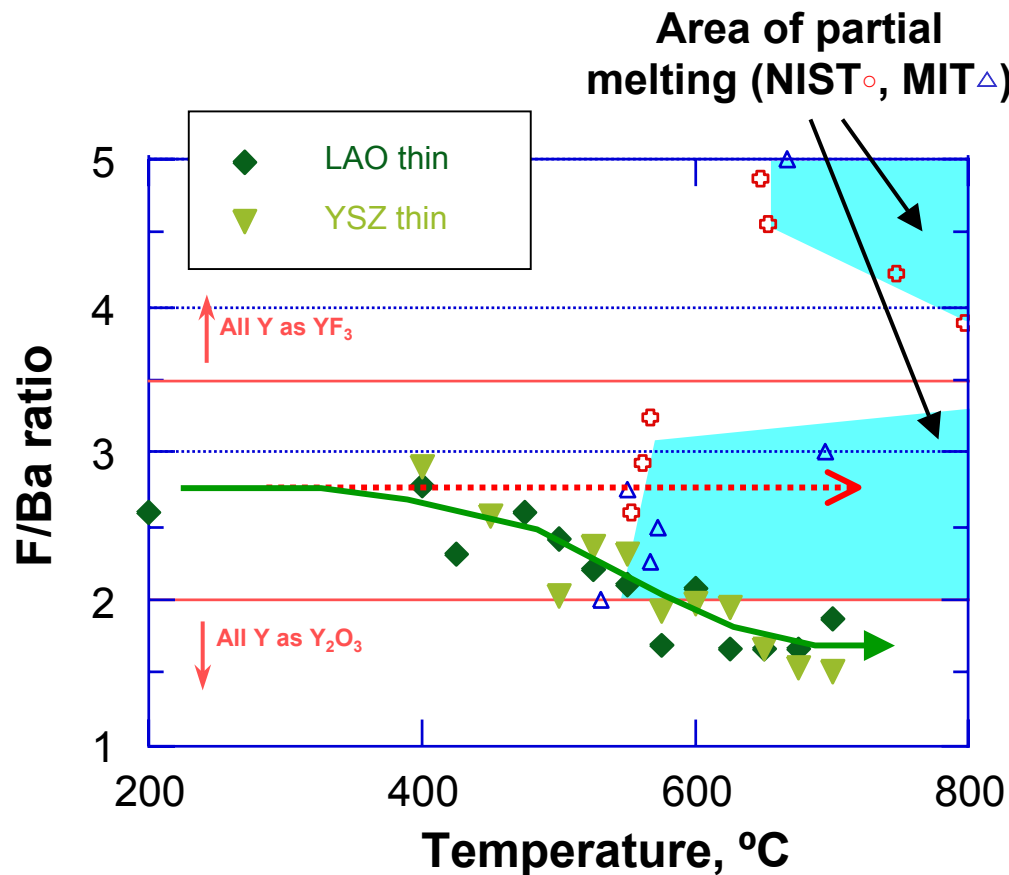
SEM image of heated at (a) 400 and (b) 1500K/min ramp rate



XRD profile of heated at 1500 and 400K/min ramp rate

Strong texture of c-oriented YBCO grains could not be obtained at 1500 K/min ramp rate

Discussion



F/Ba ratio trajectory at **low ramp rate** and **high ramp rate (estimated)**

High ramp rate is thought to prevent fluorides from decomposing prior to nucleation of YBCO

High fluoride concentrated melt has high reactivity with substrate and that might result in misorientation.

Temperature profile must be optimized for correct F/Ba ratio trajectory.